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OPERATIONS ON THE SMS SATELLITE

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PRETORIA STATION

MEMORANDUM
FROM THE PRETORIA STATION CHIEF
TO THE OPERATIONS DIVISION CHIEF

Pretoria, 1 June 1973

No. 73/87/PTA

Subject: OPERATIONS ON THE SMS SATELLITE

This memorandum is the answer to the handwritten letter of Mr. Anne. I have divided it into two parts: a theoretical part and a practical part.

All of the measuring results are attached.

1. Theoretical Aspect

1.1. Reception of Telemetering

The telemetering is of the PCM+FM/PM type emitted at 136.380 MHz with a power of 2 watts, while the satellite is still in the parking orbit.

1.1.1. Configuration of the Equipment

The proposed configuration of the equipment consists of simultaneous use of the IRIS and OSIRIS receptors; as a matter of fact our experimentation shows that the use of IRIS alone provides the same results.

The operational complications found in utilizing IRIS and OSIRIS simultaneously are only justified

--if the polarization condition is unknown or if the satellite is spun,

--if the OSIRIS controller is used (preferably in the detection position if the purists don't mind [Translator's note: this is reference to a poor French construction]: see the problem raised in regard to D2A which has never been resolved by the central services to the best of our knowledge) in order to optimize reception of the IRIG 12 channel, i.e., in the vicinity of -117 dBm, and if the IRIS controller (or the SPEC) is used to optimize the PCM reception, i.e., in the vicinity of -130 dBm.

1.1.2. Reception of the IRIG 12 Channel

In all cases the presence of the PCM, which it is impossible to filter completely, diminishes the S/N ratio leaving the tunable discriminator (see Figures 4 and 9). There can scarcely be any hope of exceeding 40 dB, which nevertheless furnishes a "signal amplitude/noise amplitude" ratio on the order of 100 and should therefore be sufficient.

Acquisition time is very rapid with OSIRIS (be careful of the lateral bands if the CAP position is used!), i.e., several seconds. The use of IRIS is very definitely limited by the phase-lock sweep velocity, at the worst 17 seconds with the 30 Hz filter.

In regards to the tunable discriminator, a slight gain is found in the S/N ratio when loop filters of 50 and 100 Hz are used; this ratio is practically the same whether the traditional FM demodulator or the coherent PM demodulator is used; the loop band of the demodulator has practically no effect.

1.1.3. PCM Reception

Experience shows that there is no recording of deterioration of probability of bit errors, whether the PCM alone or the telemeasuring combination is sent toward the synchronizer (this is logical anyway in consideration of the very high frequency of the IRIG 12 channels in comparison with the digital rhythm); therefore there is no inconvenience in working on IRIS with 5 or 50 kHz filters.

Our manipulations have shown that a very slight gain on the probability of bit error was observed when the 30 Hz filter of the phase-lock is replaced by 3 or 10 Hz filters, which was partially predictable anyway. Taking into consideration the slow sweep in the 3 and 10 Hz position (not justified by the power of the telemetering), we are tempted to work only with the 30 Hz band. It should be noted that this solution would allow working with high doppler shifts.

The IRIS phase-lock is never locked onto a lateral band; nevertheless we had formerly tried to find out if the phase-lock search area would not exceed ±6 kHz so as to avoid the IRIG 12 channel. It should be noted that our attempts were made with a common random word; perhaps this test should be repeated with a PCM registered on a satellite model.

The locking time of the primary synchronizer is also very short (1 sec); it should also be noted, nevertheless, that we had been careful to be sure that the rest frequency of the VCO was correct.

The locking time of the secondary synchronizer depends only on X_c and partially on "ID ERRORS." Practically above -135 dBm it is necessary in the case of synchronization with word ID and with $X_c = 2$ (minimum value) to count on five short cycles to obtain complete bolting, i.e., on about 15 seconds after the IRIS phase-lock locks in the case which interests us. Nevertheless, it is very possible to dispense with programming on the PCM card the information concerning the long cycles; then there will be no bolting except in the short cycle, which forces the word ID to be visualized if the information to visualize is under reversal. In the case limited to short cycle synchronization, the information to visualize is correct as soon as the phase control of the short cycle is acquired.

1.2. Remote Control Emission

Since the Schlumberger synthesizer is limited in phase modulation to a 5 kHz modulation frequency, the problem of remote control is not resolved unless some expedient like preaccentuation is used.

2. Practical Aspects

Practically, taking into account the levels deemed capable of attainment and the sensitivity curves, it appears that the real problems are

--what decision should be taken

--according to what criteria

--by whom

--and what are the consequences of an erroneous decision? In other words, is it necessary to have the decision made by two persons, to wait for confirmation of the criteria, etc...?

With the elements we possess it is difficult to take a position in regard to the feasibility of this experiment. In particular one capital element is missing: are the words to be visualized in the PCM series normally commutated or sub-commutated? From case to case the time necessary for their visualization varies considerably: between 3 seconds after IRIS locking or several minutes if there is no chance of synchronization shortly before the short cycle containing the information appears. This time is to be multiplied by two if the operator wishes confirmation of the first visualization, a desirable confirmation if the consequences of poor interpretation can be serious.

P. Foussier

APPENDIX

1. Study of the IRIG 12 Channel Alone

1.1. Mounting and Equipment Parameters

The reader should refer to Figure 1; he will see that a F1 filter of ±50 kHz has been used on OSIRIS in order to allow recording of the IRIG B channel, as is requested in SIRD, page 520.

1.2. Use of the Traditional FM Discriminator

1.2.1. OL2 in Quartz Position

An integrated PM is used.

Figure 2 summarizes the results obtained; note that it furnishes the S/N ratio directly in ordinates. We proceeded in the following way:

--the S level was fixed at 7.7 volts for maximum excursion of 7.5% (or for a frequency of 11.3 kHz).

--the N level was measured on a RMS voltmeter in the absence of modulation (or for a frequency of 10.5 kHz).

Therefore the S/N ratio given in Figure 2 corresponds to the modulation peaks; for a sinusoidal modulation signal reaching an excursion of ±7.5% at the peak, it is expedient to reduce the indicated values by 3 dB.

1.2.2. OL2 in the CAF.R Position

The results are identical.

1.3. Use of the FM Discriminator at Reduced Frequency

The 50 kHz band width is used. The results are presented in Figure 3, which is valid for both the OL2 quartz position and the OL2 CAF.R position.

An improvement of about 1 dB is found in comparison with the use of the traditional FM discriminator.

1.4. Use of the Coherent PM Discriminator

We use:

--OL2 in the CAP position

--coherent PM exit.

1.4.1. Discriminator in AUTO, CAP Position

1.4.1.1. Probability of Locking on the Lateral Band

For the three bandwidths of 100 Hz, 250 Hz and 500 Hz the probability of locking onto the lateral band (ten trials) found is given in the table below.

Level dBm	Probability of locking onto lateral ray
-114	1
-115	0.8
-116	0.7
-117	0.6
-118	0.4
-119	0.1
-120	0

1.4.1.2. Sensitivity

The results are presented in the table below:

Band	Receiver		Unlocking of the tunable discriminator
	Locking	Unlocking	
100 Hz	-131 dBm	-134 dBm	-116 dBm
250 Hz	-133 dBm	-136 dBm	-117 dBm
500 Hz	-133 dBm	-136 dBm	-118 dBm

1.4.1.3. S/N Ratio at the Exit of the Tunable Discriminator

The results are presented in Figure 4. They are completely comparable with those found by using the attenuated phase discriminator. They are identical for the three bands of 100, 250 and 500 Hz.

1.4.2. Discriminator in the AUTO, CAP + CAF Position

1.4.2.1. Probability of Locking on the Lateral Band

No locking on a lateral band was found.

1.4.2.2. Sensitivity

The following results were obtained:

Band	Receiver		Unlocking of tunable discriminator
	Locking	Unlocking	
100 Hz	-123 dBm	-126 dBm	-116 dBm
250 Hz	-123 dBm	-126 dBm	-117 dBm
500 Hz	-122 dBm	-126 dBm	-118 dBm

The results are traditional: in comparison to the CAP position, the CAP + CAF position causes a loss of about 10 dB on the locking of the receivers.

1.4.2.3. S/N Ratio at the Exit of the Tunable Discriminator.

The results are identical to those of Figure 4.

2. Study of the PCM Alone

2.1. Cards Used for Simulation (Intertechnique)

Synchro word 111100110101000000 (18 bits)

Word length: 9 bits

Length of short cycle: 63 bits

Length of long cycle: 64 bits

ID synchronization, counting, beginning, BPS, 6 bits, position: word 1

ID error: 1

Window: 1

Y_e, ..., E_V are programmed in the manual

Syllable 0: 6 bits (to visualize the word ID)

Syllable 1: 3 bits

Rhythms 1,880 bits/s (card 1) BPL

188 bits/s (card 2) BPL

2.2. Mounting Used

The mounting used, as well as the principal parameters of the equipment, are represented in Figure 5.

2.3. Probability of Bit Error

2.3.1. Tests at 1,880 Bits/s

The results are given in Figure 7. The same results were obtained with phase-lock filters of 3, 10 and 30 Hz.

2.3.2. Tests at 188 Bits/s

These results are also represented in Figure 7. In comparison with the curve of the preceding paragraph we find an improvement of 7 dB; to explain the loss of 3 dB in regard to the theory, we can note that the signals have the slope indicated in Figure 6, while also acknowledging a low valley frequency of 64 Hz.

It is easy to calculate that the energy loss is about 1 dB in the case of a series of "1", while it reaches 3 dB for a series of "10." Since the manipulation was carried out with a common random word, a loss of 1 to 3 dB may be considered normal.

We also find a slight gain (about 0.5 dB) when the 10 Hz phase-lock band is used instead of the 30 Hz band (the same results were recorded with the 3 and 10 Hz bands); this fact can be explained in the same way as above, or by taking the following facts into consideration:

--in coherent demodulation the bandwidth has a lower limit at 64 Hz for the 30 Hz band, 41 Hz for the 10 Hz band and 28 Hz for the 3 Hz band (see the Pretoria reception records, edition of October 1966, page 14).

--the low frequency energy contained in a PCM signal modulated in BPL (see the document of studies on PCM, pages 34 and 73).

Note: when the bandwidths of the phase-lock are commutated, no unlocking of the primary synchro nor of the secondary synchro is found.

3. Complete Manipulation

3.1. Diagram

The manipulation diagram is represented by Figure 8; the parameters of the equipment are the same as those of the preceding figures.

Note that the valve 7A12 of the 7514 oscilloscope has been used as a donor (the SIG.OUT exit of the 545A oscilloscope does not take direct current); the use of this equipment in the ADD position does not give rise to any problems. Nevertheless, assurance must be given of an aosence of peaking and of a choice of entry levels and of valve gains to obtain the desired modulation indices.

Caution must also be taken in respect to the fact that the exit impedance of the SIG.OUT amplitude and the modulation entry impedance of the generator ADRET are comparable (1 kΩ): therefore measurements must be made "under load."

3.2. Study of the IRIG 12 Channel

The coherent PM demodulator is used on OSIRIS; the results are given in Figure 9. Note a considerable drop in the S/N ratio, due to the presence of the PCM. Nevertheless, the locking threshold of the tunable discriminator is not changed (-117 dBm).

Note. The results are identical if a traditional demodulator is used on OSIRIS.

3.3. Study of the PCM

The same results were recorded during a study of the PCM alone; no degradation was observed.

3.4. Locking Speeds

The locking speed of OSIRIS is very rapid (several seconds); if the CAP position is used and locking is discovered on a lateral band (perceptable on the oscilloscope from -115 dBm on), several seconds must be allowed for passage to CAP + CAF to allow the central band to be found again. The direct use of the CAP + CAF position is possible (although it causes a loss of 10 dB in sensitivity, which is not annoying here), but must be avoided if the receiver is not perfectly regulated because of a possible off-center of the OL2 in the presence of noise.

In respect to IRIS, the 30 Hz band sweep rate is about 17 seconds, two minutes for the 10 Hz band; taking into account the very slight gain recorded and the probability of bit error, we are led to work in the 30 Hz band only. Final passage in the 3 Hz band, which uselessly complicates manipulation and would pose reaction time problems for the operator in case of unlocking, is to be avoided.

Locking of the primary synchronizer is immediate (about 1 second), as soon as the S/N ratio is sufficient (-135 dBm) on condition:

--that the bit rhythm is stable and known.

--that the rest frequency of the VCO has been previously checked and regulated; otherwise locking time can be high (traditional problem).

In regard to secondary consideration, refer to the manufacturer's notice; for 188 bits/s:

--A maximum of 6 seconds are needed to pass into the C.C. control phase and Xc C.C. to pass into the bolting phase.

--When work is being done with C.L. synchronization with the word ID, at lease 3 C.C. are necessary for the bolting phase to be reached, and therefore for the information to be decommutated.

In conclusion, if Xc = 2, about 21 seconds are necessary for the information to be decommutated. The SIRD document, page 5, does not specify if the information to be decommutated is supercommutated or not; therefore either 21 seconds or more than 3 minutes are needed before it can be decommutated.

4. Complementary Manipulation

We wanted to find out if the simultaneous use of IRIS and OSIRIS was really necessary; for this we tried to use only IRIS receivers.

4.1. Diagram

The installation diagram of the equipment is represented in Figure 10.

4.2. Study of the PCM

The same results were found as in paragraph 3, which, in addition, appears normal.

4.3. Study of the IRIG 12 Channel

Again the results of paragraph 3 were found.

5. Use of OSIRIS Alone

The use of OSIRIS alone does not pose any particular problem concerning the IRIG 12 channels; on the other hand, in regard to the PCM:

--it is absolutely necessary to work with coherent demodulation equipped with a 100 Hz filter; all of the other configurations absorb far too much of the low frequencies,

--the sensitivity of the primary synchronizer drops by about 20 dB, which is quite a bit: there can be no hope of working below about -115 dBm. No satisfactory explanation has been found, and the low frequency energy loss is not sufficient to explain such a loss.

6. Study of Emission

6.1. Remarks on the FS 500

According to the notice the FS 500 is limited in respect to FM or PM modulation to a modulation frequency of .5 kHz; nevertheless, so as to allow the study of the emitter which you have asked of us, we began by studying to what extent it was possible to obtain the desired modulation on the FS 500 by increasing at need the level of the modulating BF frequency.

Figure 11 gives the multiplying factor to be used when it is desirable to modulate the FS 500 with BF frequencies greater than 4 kHz: we see that, to modulate with a BF frequency of 20 kHz, it is necessary to multiply the BF entry level by 7!

This manipulation was carried out in the following way:

--use of the FS 500 alone, set at 136.000 MHz and striking an IRIS receiver by means of an attenuator.

--striking the EXT. MOD. entrance of the FS 500 by a BF generator.

--regulation of the PM modulation index at 0.15 radians, corresponding to an exit level on the IRIS coherent PM demodulation of 400 mV c/c (bandwidths fixed at 150 kHz)

--the frequency of the BF generator was varied and measurement is made of the multiplying factor needed to multiply the exit level of this generator to always obtain 400 mV c/c at the IRIS coherent PM exit.

This multiplier factor is seen in Figure 11.

6.2. Study of the Emitter

Next the FS 30 + FS 500 assembly is regulated so as to obtain a frequency of 24.666 MHz able to be modulated in PM:

--FS 500 on 141 MHz

--FS 30 on 24.666 MHz.

The diagram of the manipulation is next represented in Figure 12. Then the exit level of the coherent PM demodulation is plotted along with its rate of distortion as a function of frequency by multiplying the exit level of the BF generator by the multiplier factor given in paragraphs 6.1. The measurement results appear in Figure 13.

6.3. Conclusion

It finally appears

--that the FS 30 cannot be used for the proposed operation unless a delicate expedient is used,

--that the emitter can be used as a multiplying amplifier of a PM modulated frequency up to a modulation frequency of about 20 kHz.

Nevertheless, in consideration of the complexity of the manipulation, the above results are given reservedly; it would be expedient to review them on a more systematic basis.

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